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	Patents ADP number *(if you know it)*	~~1867002~~ 6300388001
	If the applicant is a corporate body, give the country/state of its incorporation	UNITED KINGDOM
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DUPLICATE

TELEPHONE EXCHANGE CABLING

This invention relates to telecommunications exchange installations and methods of creating a connection and re-routing connections in such exchange installations.

A typical telephone exchange building houses a large variety and quantity of equipment such as switches, typically on equipment racks, and connected by cables to and from each other and to the external telecommunications network. In modern exchanges it is becoming almost universal for the cabling to take the form of optical fibre due to its superior carrying capacity, ease of handling and other advantages.

One of the main functions of optical fibre plant within an exchange is to manage and route fibres from a particular set of optical equipment to fibres from, for example, an incoming cable from the external telecommunications network. As optical fibre is deployed more abundantly and more deeply into the network, the routing and patching of such fibre, especially within exchanges, is becoming increasingly complicated and expensive. A major problem is the sheer number of connections and equipment already in place. The problem is exacerbated by growth, upgrading and changes within the exchange which result in the need to interconnect new equipment or systems. Although the physical positions of incoming cables rarely change, the new equipment or system will almost certainly be in a different physical location from the old. There is also need to easily re-route when cabling errors are made.

The current method of fibre routing within the exchange is achieved with Optical Flexibility Racks (OFRs), which serve as junction or distribution points allowing cables to be routed within the exchange. OFRs can carry hundreds of individually spliced fibres but when they are fully populated, as is often the case, there is severe congestion along the cable at the OFRs. It is often difficult to identify, locate and isolate fibres in such cases when re-routing of the cable path is necessary, making the task both time-consuming and complicated. Another problem resulting from fibre overcrowding is that they are routed across each other in close proximity so that the combined weight presses down on fibres located near the base of OFRs, increasing the risk of fibre breakage. This problem will become even more critical when high bit rate systems are employed.

The installation and maintenance of optical fibre cabling, their routing and supporting structures such as OFRs take up a significant portion of the total cost, time

and effort of installing and cabling the telephone exchange system. Current methods to connect exchange equipment to each other, or to an incoming cable to a rack of exchange equipment typically involve a number of fibre lengths connected end to end either by means of connectors or splices. The path taken by the fibre from the incoming cable to an equipment rack could involve a significant number of connections or splices, especially if the destination equipment rack is physically distant from the incoming cable, for example if the equipment sits on a separate floor from the incoming cable within the exchange building.

Such conventional methods are commonly known and described in e.g. *Modular Optical Plant for Access Network: Operational Aspects* by D. Brewer et. al (Proc. EFOC & N (Technology and Infrastructure) 1995, at pages 164-167).

Problems associated with the existing method of creating fibre paths by using connectors or splices arise from the inherently delicate nature of joining fibre ends, which is time- and cost-consuming in the need for specialist equipment and expertise. Connections and splicing also inevitably involve optical losses regardless of the quality of the join, as the re-joining is unlikely ever to realign the severed fibre ends perfectly. Other problems could arise: for example, stored fibre could "run out" either side of the splice, thereby reducing the number of fibre turns.

In a first aspect, the present invention provides a telecommunications switch installation comprising a telecommunications switch connected to an optical fibre of an incoming cable connected to and incoming from a telecommunications network, terminated at a primary flexibility suite, via a secondary flexibility suite, where the primary and secondary flexibility suites include means for routing joined blown fibre tubes within the installation, the joined blown fibre tube comprising ends of lengths of blown fibre tube joined to form a path from the primary flexibility suite, a continuous blown fibre unit extending through the joined blown fibre tubes, and connecting the telecommunications switch to the primary flexibility suite, thereby providing an optical path between the switch and the optical fibre of the incoming cable.

In a second aspect, the present invention a method of creating a method of creating a connection in a telecommunications switch installation, between a telecommunications switch, and an optical fibre of an incoming cable connected to and incoming from a telecommunications network, terminated at a primary flexibility suite, comprising the steps of: installing lengths of blown fibre tube and joining the ends of the lengths of blown fibre tube to form a path from the primary flexibility suite to the

telecommunications switch via a secondary flexibility suite, where the primary and secondary flexibility suites include means for routing joined blown fibre tubes within the installation, and thereafter, installing, by blowing, a continuous blown fibre unit through the path formed by the joined blown fibre tubes, thereby providing an optical path between the telecommunications switch and the optical fibre of the incoming cable.

In a third aspect, the present invention provides a method of re-routing an existing connection in a telecommunications switch installation from a connection between a first telecommunications switch and a primary flexibility suite, to create a connection between a second telecommunications switch and the primary flexibility suite comprising the steps of: breaking the a connection between the first telecommunications switch and the primary flexibility suite at the primary flexibility suite, installing lengths of blown fibre tube and joining the ends of the lengths of blown fibre tube to form a path from the primary flexibility suite to the secondary telecommunications switch via a secondary flexibility suite, where the primary and secondary flexibility suites include means for routing joined blown fibre tubes within the installation, and thereafter, installing, by blowing, a continuous blown fibre unit through the path formed by the joined blown fibre tubes thereby providing an optical path between the second telecommunications switch and the optical fibre of the incoming cable.

Embodiments of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic drawing of a exchange installation using optical fibre cables according to the current conventional method;

Figures 2A and 2B are schematic drawings showing the existing method of re-routing the path between an incoming cable and the destination equipment rack using optical fibre cables according to the current conventional method;

Figure 3 is a schematic drawing of an exchange installation according to the present invention;

Figures 4A and 4B are schematic drawings showing a method of re-routing the path between an incoming cable and the destination equipment rack according to the present invention;

Figure 5 is a schematic drawing of another embodiment of an exchange installation according to the present invention;

Figure 6 is a schematic drawing of a further embodiment of an exchange installation according to the present invention;

Figures 7A to 7F show configurations of blown fibre flexibility tube modules (BFTFMs) in single-, two-, three-, four-, five- and six-module builds respsectively; and

Figure 8 shows a typical build sequence of an exchange installation of the type as shown in Figure 3 above.

Figure 1 shows a typical layout of the current exchange installation of a particular equipment rack (2) within the exchange building, connected to an incoming cable (5). For the avoidance of doubt, an "incoming cable" includes any cable which enters the exchange to connect it with, for example the external telecommunications network.

The incoming cable (5) is typically terminated at a cable chamber joint (CCJ) (8) by a splice (10f) to an internal cable (1c). The CCJ is typically located within same building as the equipment rack although this is not necessarily the case. The CCJ represents the "line side" of the exchange for purposes of fibre routing within the exchange. The equipment rack represents the "equipment side" for purposes of fibre routing within the exchange.

The internal cable (1c) is spliced at one end to the incoming cable at the CCJ, and the other end to a line side flexibility point such as an Optical Flexibility Rack (OFR) (4d).

Flexibility points serve various functions, mainly as a junction or distribution point to connect any point to any point within the exchange e.g. from any piece of exchange equipment to any other piece of equipment, or from/to an incoming cable. Flexibility points also provide an interface between the high fibre count incoming cable and an internal cable, terminates incoming fibres onto splice trays for safe storage, and provide easy access to each individual fibre and serves as a testing point. We are however for present purposes interested only in their ability to connect line side fibre to equipment side fibre. Typically, at least two flexibility points are used together, more usually in side-by-side pairs, to facilitate the routing of fibres within the exchange – one on the line side and one on the equipment side. Such groupings of flexibility points are within this document called flexibility suites. For the avoidance of doubt, "flexibility points" and "flexibility suites" in this discussion are generic references to OFRs and OFR suites for fibre cables, and to Blown Fibre Flexibility Modules (BFTFMs) and BFTFM suites (discussed below in connection with Figure 3 onwards).

OFR suites (4a and 4b, 4c and 4d) allow fibres terminated in line side flexibility points and equipment side flexibility points to be spliced to each other on a splice tray dedicated to a fibre or pair of fibres. Single fibre cable tails (3a, 3b) are spliced between the pair of OFRs. Another fibre cable (1b) connects an equipment side OFR (4c) to the next line side OFR (4b). The first OFR suite (comprising 4c and 4d) in Figure 1 is located near the CCJ, and the last suite (comprising 4a and 4b) is those located near the destination equipment rack. In an actual exchange, a number of OFR suites distribute and route optical cable; the "last OFR suite" (comprising 4a and 4b) would be the suite located closest to the destination equipment rack (2).

Figure 1 shows the most basic layout involving two pairs of OFRs. In practice, depending on the exchange building layout and the complexity and length of the optical path, any number of OFR suites can be used to describe the optical path to the equipment rack, which would have an effect the number of OFR suites and splices or connections in the optical path. For the basic configuration shown in Figure 1, a minimum of six splices (10a to 10f) is required.

Figures 2A and 2B illustrate how, according to current practices, an optical path is re-routed from a first equipment rack (2) to second equipment rack (12) in a conventional optical fibre installation.

In the installation shown in Figure 2A, an optical path connects the incoming cable (5) to the existing equipment rack (2). There are five splices (10a to 10g) along the path through two OFR suites (4). To re-route the optical path to the new equipment (12) at a different location, five splices (10a to 10g) will have to be broken in the old path. Figure 2B shows the optical path to the new equipment rack (12) through two OFR suites (4). Five new splices (10h to 10m) are made to create the new optical path from the line side OFR (4d) adjacent to the CCJ (8). As discussed above, splicing is a complicated and delicate procedure requiring considerable specialist skill. Splices will inevitably result in signal attenuation and the creation of new splices will necessarily involve the risk of a poorly-made join in the optical path. The cable used in the old optical path will be removed and if not suitable for re-use, as is often the case, it will be discarded.

Figure 3 shows a first embodiment of the invention. Instead of separate lengths of fibre connecting the OFRs which need to be joined (e.g. 1a, 3a, 1b, 3b and 1c in Figure 1), a blown fibre unit (BFU) is installed describing most of the path from

the CCJ (8) to the equipment rack (2) to effect the connection between the incoming cable (5) and the equipment rack (2).

The incoming joint (5) is terminated at a line side OFR (4) in the usual way as described in connection with Figure 1 above. An internal cable (1) is spliced to the incoming cable at the CCJ and is spliced at its other end on a splice tray housed in a conventional line side OFR (4) in the usual way as described in connection with Figure 1 above. From the line side OFR (4), lengths of blown fibre tube (BFT) (16) are patched through to the equipment rack (2) via a number of flexibility points for BFTs which in this case are called Blown Fibre Tube Flexibility Modules (BFTFMs) (14), comprising a single tube and push in BFT connectors. As noted above in connection with Figure 1, BFTFMs are flexibility points allowing the distribution and routing of – in this case – blown fibre tubes throughout the exchange from any point to any point. As with OFRs, BFTFMs are most commonly employed in suites, one on the line side (14b) and one on the equipment side (14a). The OFM (4) at which the incoming cable is spliced forms one half of a flexibility suite, the other half being a BFTFM (14c) on the equipment side.

The BFTs (16a, 16b) in this embodiment are installed between one equipment side BFTFM to the next line side BFTFM along the path to the equipment rack. The path is completed by installing single tube BFT patch leads (17a, 17b) between the flexibility suites (14c and 4, 14a and 1b), so that a completed BFT path is created between the OFR (4) and the equipment rack, ready to receive a BFU. BFU is then installed by blowing from either end of the path, i.e. from the equipment rack (2) or from the OFR (4).

Figure 3 shows just two flexibility suites in use, but as discussed above, further flexibility suites can be employed depending on the physical distance, building layout and path taken from the originating point to the destination point.

By way of example, if the scenario involves the CCJ (8) being located on the ground floor, and the equipment rack (2) on the first floor, the installation could involve the following steps:

1. Install the CCJ.
2. Terminate incoming cable on CCJ.
3. Install internal cable between CCJ and OFR.
4. At CCJ splice all fibres from incoming cable to internal cable.
5. At OFR terminate all fibres on a line side OFR.

6. Install BFT from equipment side of ground floor BFTFM (located adjacent to OFR) to line side BFTFM on first floor.
7. Install BFT from equipment side of first floor BFTFM to line side BFTFM on second floor; repeat for all floors.
8. Finally on the floor where the relevant equipment is located, install BFT from the equipment rack to the equipment side of an BFTFM.
9. Patch BFT path through all BFTFMs using single BFT, cut to length on site.
10. Install BFU. Blowing can be carried out at either the equipment rack or at the OFR.
11. At the OFR splice internal cable to the installed BFU.
12. At the equipment rack splice connectorised pigtails to the installed BFU.

It would be clear to the skilled person that a major advantage of using a single unbroken length of blown fibre unit to interconnect optical equipment to the external network, is a significant improvement in signal transmission. In the basic arrangement described in this Figure 3, there are only three splices (10a, 10b, 10c) per fibre between the CCJ and the equipment rack, compared to five in the conventional arrangement described in Figure 1. Time- and cost-savings are achieved as expensive and delicate splicing and connectorising is reduced to a minimum.

Figures 4A and 4B shows how an optical path connecting an existing equipment rack (2) can be changed to the new equipment rack (12) in accordance with the invention.

Figure 4A shows the existing optical path between the incoming cable (5) and the old equipment rack (2) though two flexibility suites (14). Figure 4B shows how only two splices (10a, 10b) have to be broken in the existing optical path, which compares favourably with equivalent under the conventional method which requires five breaks (see Figure 2). After the splices are broken the blown fibre unit is removed or recovered. The path is then re-configured, using BFT (16) between flexibility suites (14d and 14e, 14c and 4), and single tube BFT patch leads (17c, 17d) between the flexibility points within a suite. BFU is then installed as described above in connection with Figure 3, by blowing from either end of the path, i.e. from the new equipment rack (12) or from the OFR (4). Only two new splices are made (10c, 10d) at the OFM and the new equipment rack.

It can be seen that yet another advantage of the invention is flexibility in re-routing and user-friendliness, compared to conventional techniques requiring pulling and splicing of heavy cables. The resulting blown fibre installation is relatively compact, particularly when compared to fibre connectors, which offers flexibility at the cost of attenuation and bulk. Blown fibre units are more easily transported and hardy; the process of installing the optical fibre is "de-skilled" to some extent resulting in greater cost-effectiveness.

Figures 5 and 6 show refinements of the arrangements described in Figure 3 above, being embodiments of the invention which further reduce the number of splices required.

In Figure 5, the CCJ (5) and the splice thereat is removed. The incoming cable (5) is instead directly spliced to the blown fibre unit (when installed) at the line side OFR (4). In this arrangement, there are only two splices per fibre. By way of example, the following are typical steps that can be taken to create this installation where the incoming cable enters the building on the ground floor and the equipment racks are located on the first and second floors:

1. Route incoming cable from cable chamber to the OFR.
2. Terminate all fibres of the incoming cables on the line side OFR. Install BFT from equipment side of ground floor BFTFM (located adjacent to OFR) to line side BFTFM on first floor.
3. Install BFT from equipment side of first floor BFTFM to line side BFTFM on second floor; repeat for all floors.
4. Finally on the floor where the relevant equipment is located, install BFT from the equipment rack to the equipment side of an BFTFM.
5. Patch BFT path through all BFTFMs using single BFT, cut to length on site.
6. Install BFU. Blowing can be carried out at either the equipment rack or at the OFR.
7. At the OFR splice internal cable to the installed BFU.
8. At the equipment rack splice connectorised pigtails to the installed BFU.

The arrangement in Figure 6 allows a connection between the equipment rack (2) and the incoming cable (5) with just a single splice (10) at the OFR (4). In this

case, BFT is installed directly from the equipment rack to the equipment side of the BFTFM located nearest to the equipment rack (14a). BFU is installed in the manner discussed above against Figure 3. By way of example, the following are typical steps that can be taken to create this installation where the incoming cable enters the building on the ground floor and the equipment racks are located on the first and second floors:

1. Route incoming cable from cable chamber to the OFR.
2. Terminate all fibres of the incoming cables on the line side OFR.
3. Install BFT from equipment side of ground floor BFTFM (located adjacent to OFR) to line side BFTFM on first floor.
4. Install BFT from equipment side of first floor BFTFM to line side BFTFM on second floor; repeat for all floors.
5. Finally on the floor where the relevant equipment is located, install BFT from the equipment rack to the equipment side of an BFTFM.
6. Patch BFT path through all BFTFMs using single BFT, cut to length on site.
7. Install pre-connectorised BF; blowing to be carried out at equipment rack.
8. At the OFR splice external cable to BFU.

Figures 7A to 7F respectively show BFTFM suites in various configurations from a single module to a six-module build. These show that while a single BFTFM may be used as a flexibility point, multiple-modules are preferred and their modularity allows flexibility in use and scope for growth.

Figure 7A shows a single module BFTFM. Two versions are available that allow cable entry from left or right. The example shown allows cable to be fed from the left. A single unit like this would be mounted on the back of a flexibility point such as an OFR to provide the first building block of flexibility suite, in particular the suite most adjacent to the CCJ or the incoming cable.

Figure 7B shows two BFTFM modules mounted back to back to create a line and equipment side flexibility suite. Generally, two modules are the minimum requirement to provide line and equipment side flexibility.

Figure 7C shows a further BFTFM module mounted on top of the arrangement of Figure 7B. Such an arrangement may be required for example, where there is uneven growth of the demand for the equipment side modules, compared to that for line side modules.

Figure 7D shows that further build can also be carried out to the side from one end of the suite. In this case as cable entry is from the left hand side, further modules would be added to the right.

Figures 7E and 7F show five- and six-module configurations to illustrate the potential for growth in the use of BFTFMs.

Figure 8 shows a typical build sequence for the installation described in Figure 6 above using the Modified OTIAN™ Generic Rack 4A. The following steps accord with the numbering against the drawings:

Installing first flexibility suite (4 and 14c of Figure 3)

1. Install Generic Rack 4A (rear covers have been removed in the drawing for clarity) (4). Install incoming cables (5) and terminate fibres on single circuit splice trays. Cables can enter either from above or below. This modified GR4A is approximately 2.6m high with a capacity of 1152 fibres.
2. Install one BFTFM (14c) adjacent to the rear of GR4A. Each BFTFM can accommodate 384 BF tubes, the equivalent of 4x96 fibre cables. A second and third BFTFM can be added to the flexibility suite to accommodate a maximum of 1152 BF tubes.
3. Install vertical cable tray (20), mandrel adaptor (22) and internal bend mandrel (24). In this instance the cable routes upwards.

Installing subsequent secondary flexibility suite (e.g. 14a and 14b of Figure 3)

4. Install vertical cable tray (26), support frame uprights (28) and frame strap (30) on exchange floor.
5. Add outer bend mandrel (32) and line side BFTFM (14b).
7. Install second vertical cable tray (26), equipment side BFTFM (14a), mandrel adaptor and internal bend mandrel.
8.

The secondary flexibility suite is now ready to accept BF tubing. The installation shown can accommodate up to 384 BF patch tubes.

Installing BF tubing

8. The butt of the BF tube (16) is cut level with the edge of the BFTFM (14). Each tube contained is routed over the plastic tube mandrels. Tubes are cut

to length and plugged into the push fit bulk head fittings which are in turn located into the appropriate hole in the patch panel.

9. Illustration of interface with the vertical cable tray - upwards.

10. Illustration of interface with the vertical cable tray - downwards.

Although the foregoing discussion concerns mainly a connection created by the invention between an equipment rack and an incoming cable connecting the exchange to the external telecommunications network, the skilled person would easily recognise that the invention can be deployed with similar effects or advantages to connect any other originating point to any destination point within or outside of the exchange. Furthermore, while the specific description the made in the context of telecommunication exchange buildings, it would be clear that the invention can have applications in any other environment where blown fibre technology according to the invention can be used in place of convention connected or splice optical fibre. In particular, the invention may be used in a Local Area Network (LAN) environment. The skilled person would also find it obvious that the inventive aspect concerning re-routing of optical paths can be applied even in a conventional installation using splices, so as to realise the benefits of using the invention as described herein.

Claims:

1. A telecommunications switch installation comprising a telecommunications switch connected to an optical fibre of an incoming cable connected to and incoming from a telecommunications network, terminated at a primary flexibility suite, via a secondary flexibility suite, where the primary and secondary flexibility suites include means for routing joined blown fibre tubes within the installation, the joined blown fibre tube comprising ends of lengths of blown fibre tube joined to form a path from the primary flexibility suite, a continuous blown fibre unit extending through the joined blown fibre tubes, and connecting the telecommunications switch to the primary flexibility suite, thereby providing an optical path between the switch and the optical fibre of the incoming cable.

2. An installation according to claim 1 wherein the primary flexibility suite includes a optical flexibility point and a blown fibre tube flexibility point located in proximity to each other, and the secondary flexibility suite includes a plurality of blown fibre flexibility points located in proximity to each other.

3. An installation according to either claims 1 or 2 wherein the primary flexibility suite is located in proximity to a cable of the telecommunications network.

4. An installation according to any preceding claim including a plurality of secondary flexibility suites.

5. An installation according to any preceding claim wherein the ends of lengths of blown fibre tube are joined at the flexibility suites.

6. An installation according to any preceding claim wherein the telecommunications switch is housed in an equipment rack.

7. An installation according to any preceding claim including a plurality of telecommunications switches connected to the optical fibre of the incoming cable via the primary and secondary flexibility suites.

8. An installation according to any preceding claim including a plurality of incoming cables.

9. An installation according to any preceding claim wherein the incoming cable is spliced to a cable of the telecommunications network at a cable chamber joint.

10. A method of creating a connection in a telecommunications switch installation, between a telecommunications switch, and an optical fibre of an incoming cable connected to and incoming from a telecommunications network, terminated at a primary flexibility suite, comprising the steps of:
installing lengths of blown fibre tube and joining the ends of the lengths of blown fibre tube to form a path from the primary flexibility suite to the telecommunications switch via a secondary flexibility suite, where the primary and secondary flexibility suites include means for routing joined blown fibre tubes within the installation, and thereafter, installing, by blowing, a continuous blown fibre unit through the path formed by the joined blown fibre tubes, thereby providing an optical path between the telecommunications switch and the optical fibre of the incoming cable.

11. A method of re-routing an existing connection in a telecommunications switch installation from a connection between a first telecommunications switch and a primary flexibility suite, to create a connection between a second telecommunications switch and the primary flexibility suite comprising the steps of:
breaking the a connection between the first telecommunications switch and the primary flexibility suite at the primary flexibility suite, installing lengths of blown fibre tube and joining the ends of the lengths of blown fibre tube to form a path from the primary flexibility suite to the secondary telecommunications switch via a secondary flexibility suite, where the primary and secondary flexibility suites include means for routing joined blown fibre tubes within the installation, and thereafter, installing, by blowing, a continuous blown fibre unit through the path formed by the joined blown fibre tubes thereby providing an optical path between the second telecommunications switch and the optical fibre of the incoming cable.

12. A method according to either claims 10 or 11 where the primary flexibility suite includes a line-side optical flexibility point and an equipment-side blown fibre tube flexibility point located in proximity to each other, and the secondary flexibility suite

includes a line-side blown fibre flexibility point and an equipment-side blown fibre flexibility point located in proximity to each other, wherein the path from the primary flexibility suite to the telecommunications switch is formed by installing a blown fibre tube from the equipment-side blown fibre flexibility point in the primary flexibility suite to the line-side blown fibre flexibility point in the secondary flexibility suite, installing a blown fibre tube from the equipment-side blown fibre flexibility point in the secondary flexibility suite to the telecommunications switch, and installing blown fibre tube connectors from the line-side flexibility point to the equipment-side flexibility point in flexibility suite.

13. A method according to any of claims 10 or 12 wherein the continuous blown fibre unit is installed by blowing from an equipment rack housing the telecommunications switch.

14. A method according to any of claims 10 to 13 wherein the continuous blown fibre unit is pre-connectorised.

15. A method according to any of claims 10 to 13 wherein the continuous blown fibre unit is installed by blowing from the line-side optical flexibility point of the primary flexibility suite.

16. An installation substantially as described in accordance with the drawings.

17. A method of creating a connection in a telecommunications switch installation substantially as described in accordance with the drawings.

18. A method of re-routing an existing connection in a telecommunications switch installation substantially as described in accordance with the drawings.

ABSTRACT

TELEPHONE EXCHANGE CABLING

A telecommunications switch installation comprising a telecommunications switch connected to an optical fibre of an incoming cable connected to and incoming from a telecommunications network, terminated at a primary flexibility suite, via a secondary flexibility suite, where the primary and secondary flexibility suites include means for routing joined blown fibre tubes within the installation, the joined blown fibre tube comprising ends of lengths of blown fibre tube joined to form a path from the primary flexibility suite, a continuous blown fibre unit extending through the joined blown fibre tubes, and connecting the telecommunications switch to the primary flexibility suite, thereby providing an optical path between the switch and the optical fibre of the incoming cable.

(FIGURE 3)

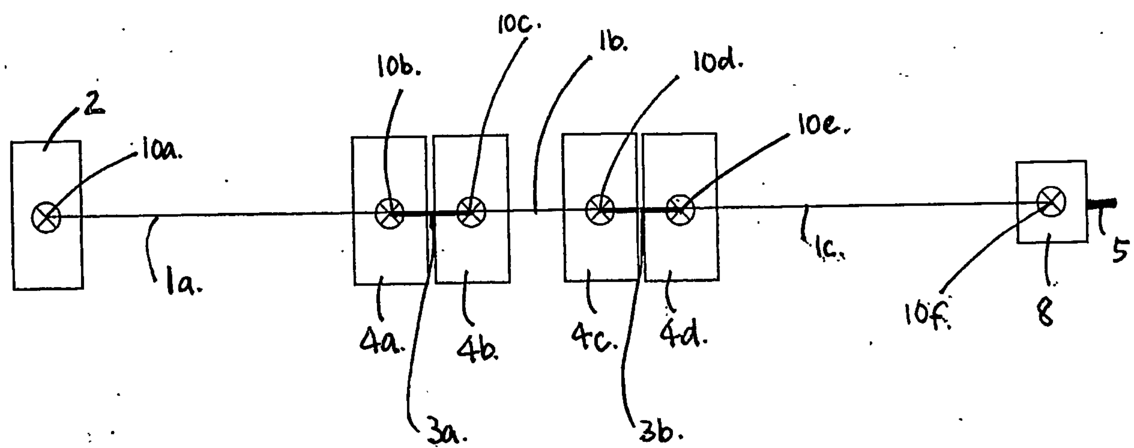

FIGURE 1

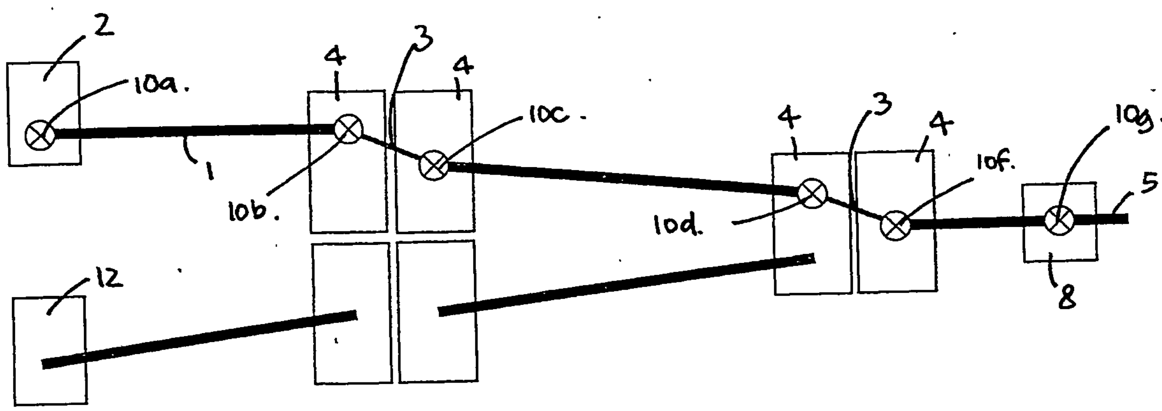

FIGURE 2A

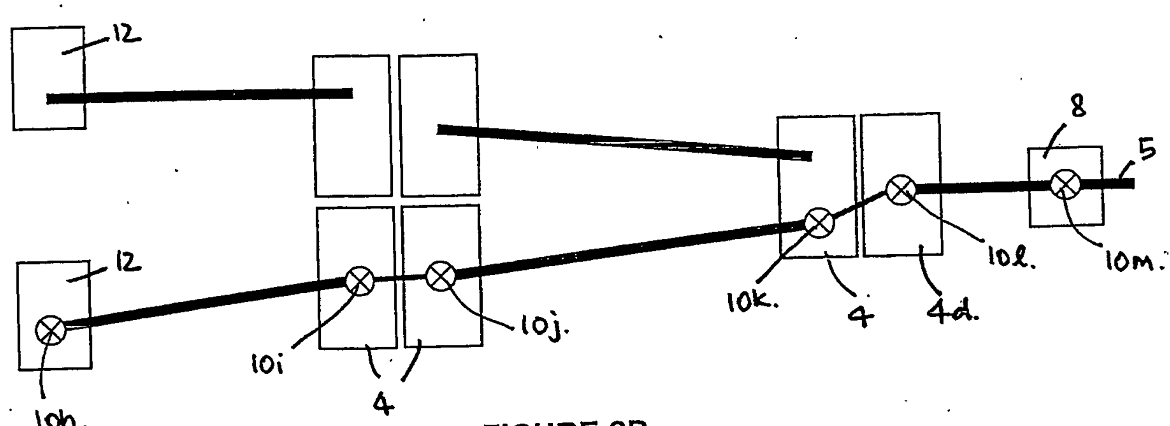

FIGURE 2B

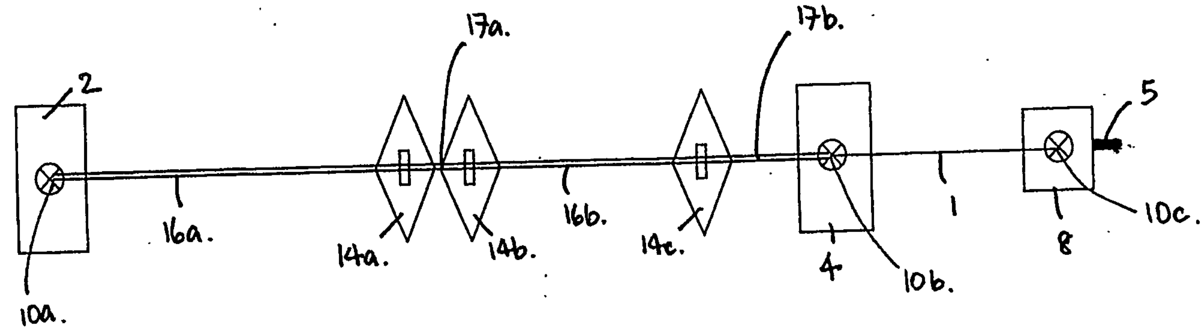

FIGURE 3

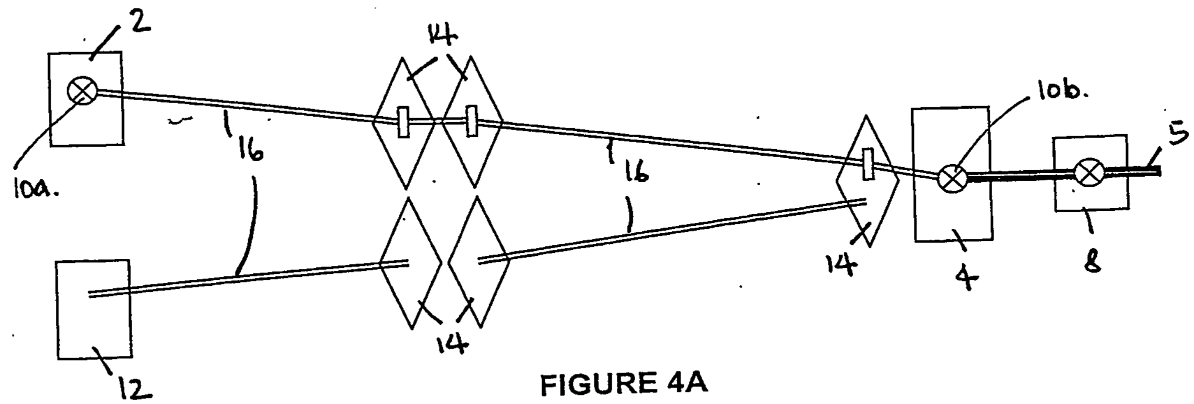

FIGURE 4A

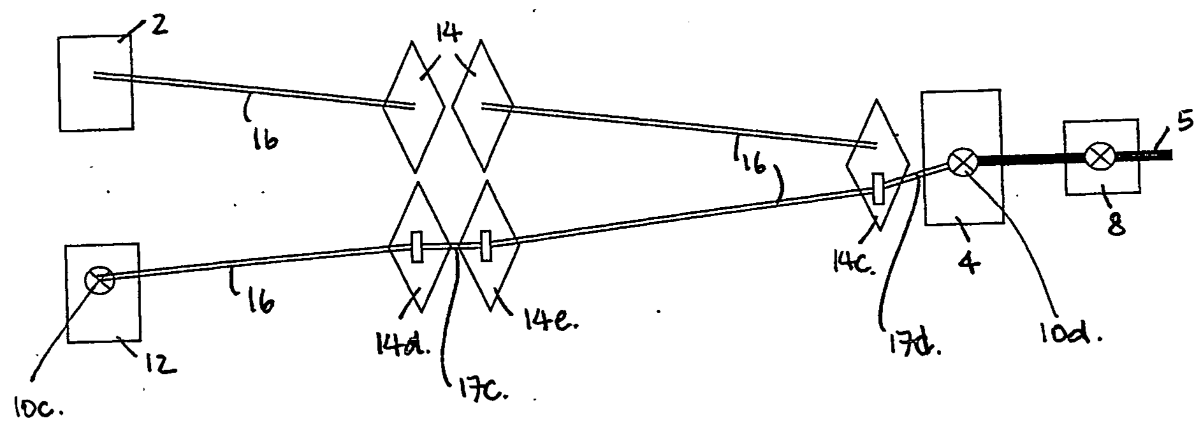

FIGURE 4B

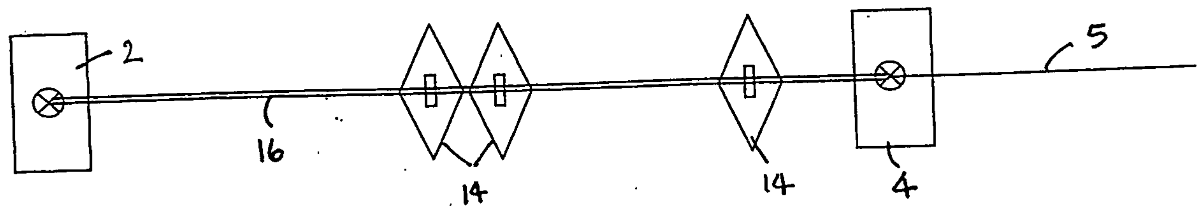

FIGURE 5

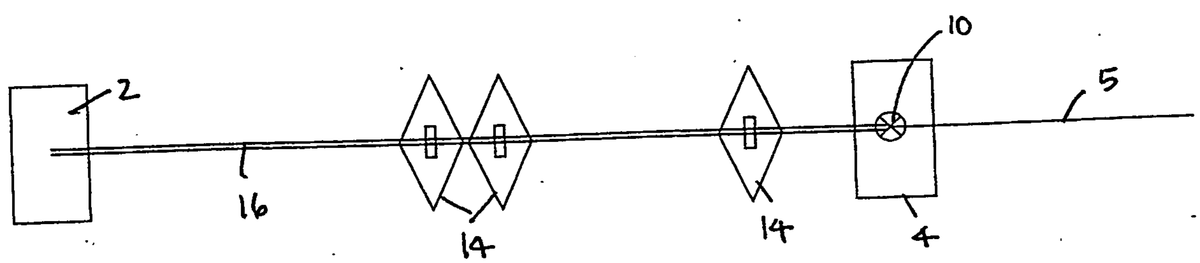

FIGURE 6

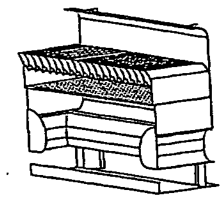

FIGURE 7A

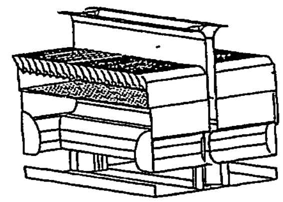

FIGURE 7B

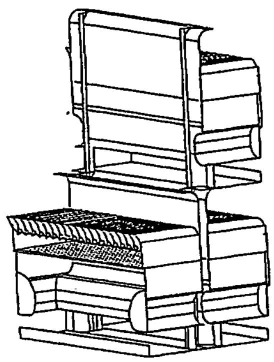

FIGURE 7C

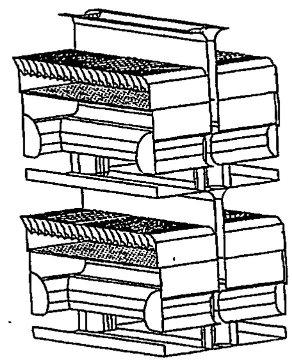

FIGURE 7D

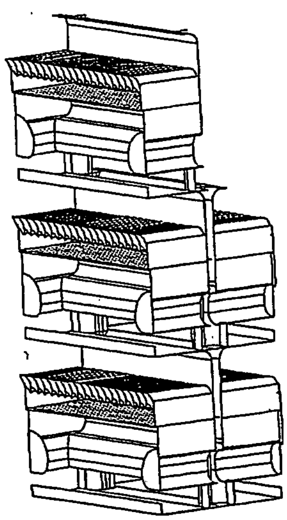

FIGURE 7E

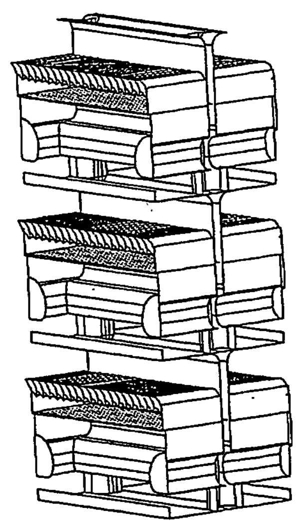

FIGURE 7F

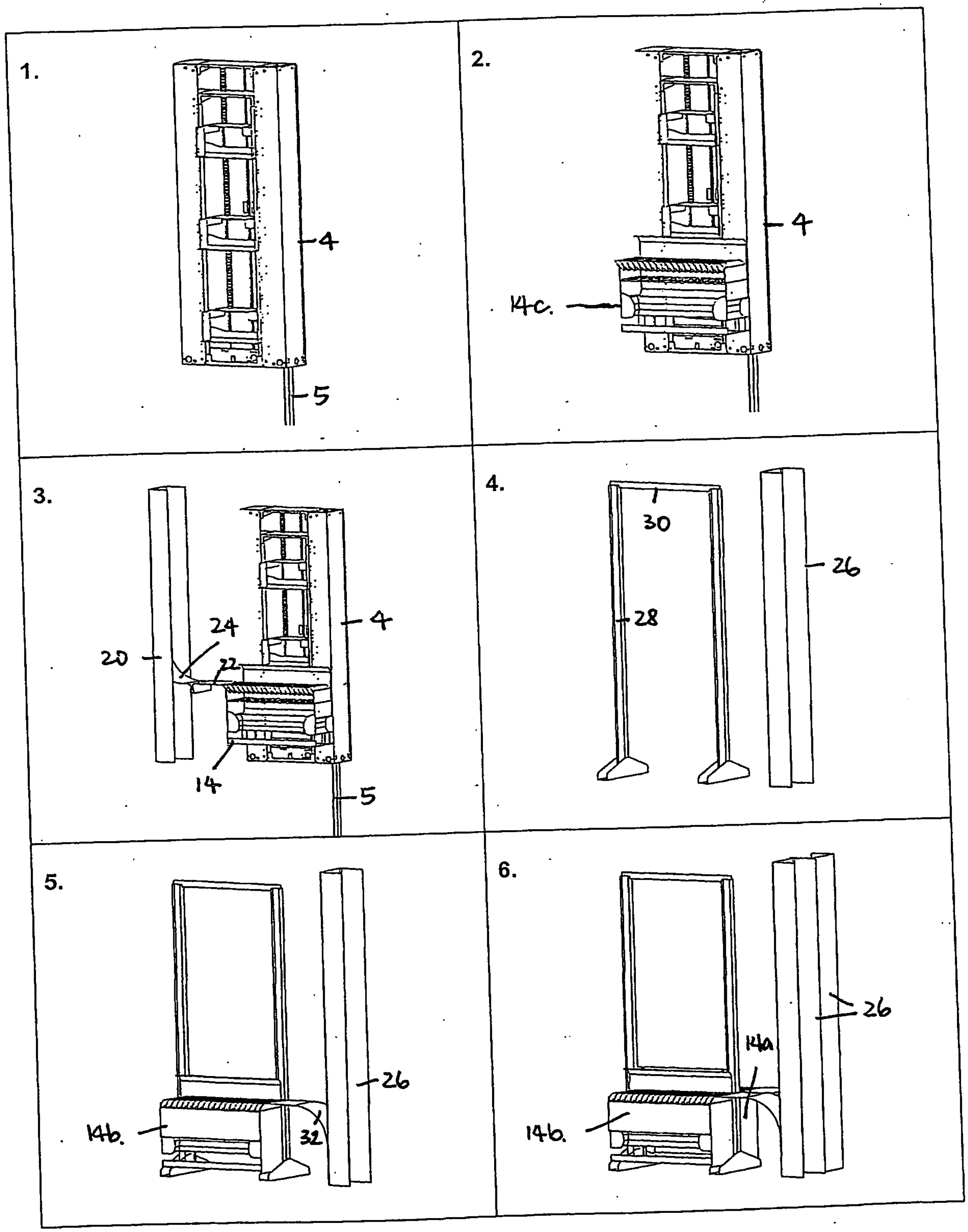

FIGURE 8

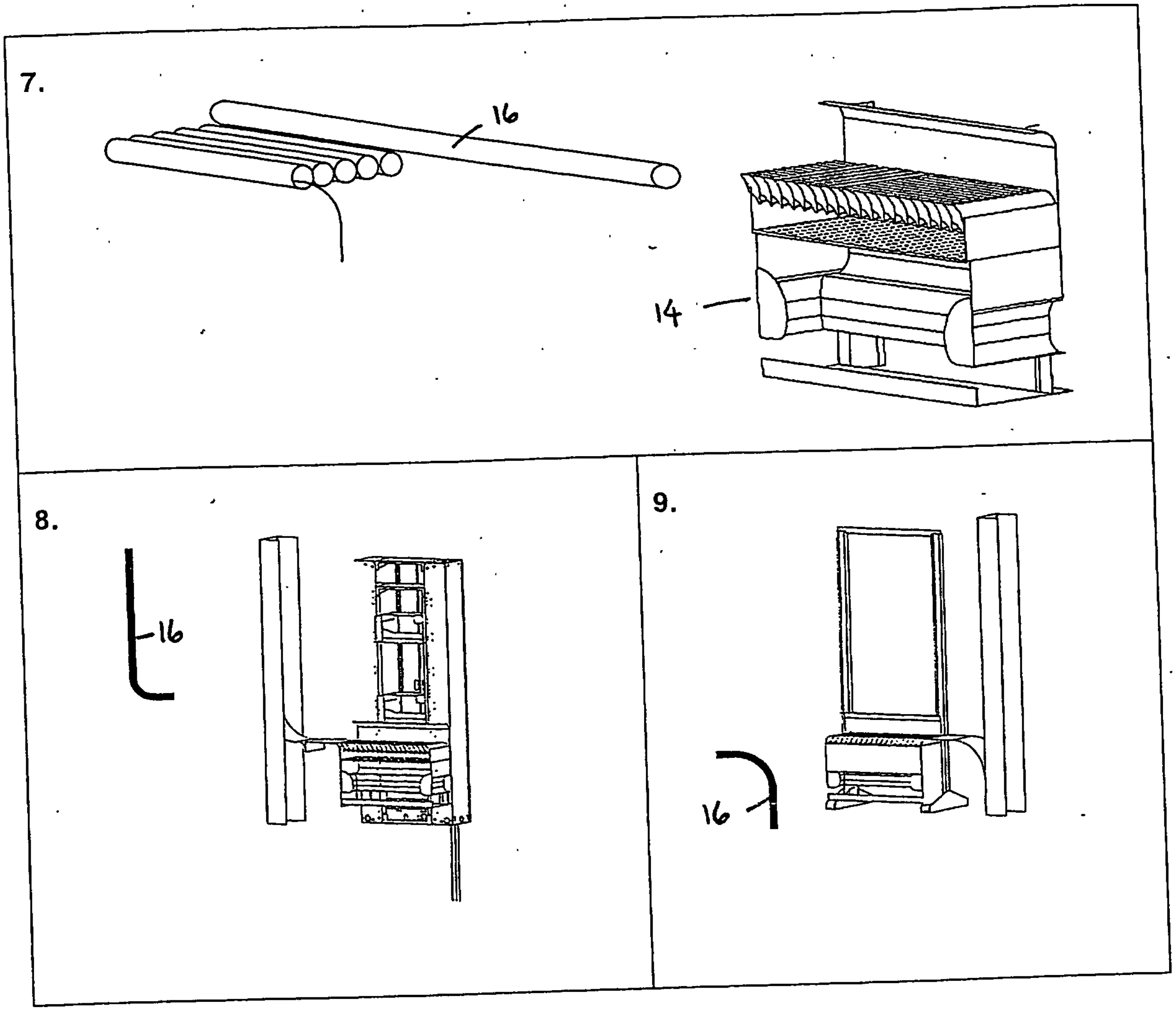

FIGURE 8

PCT/GB2004/001370